BP

...not British Petroleum
but "Big Proton" plan
V.Shiltsev

Goals

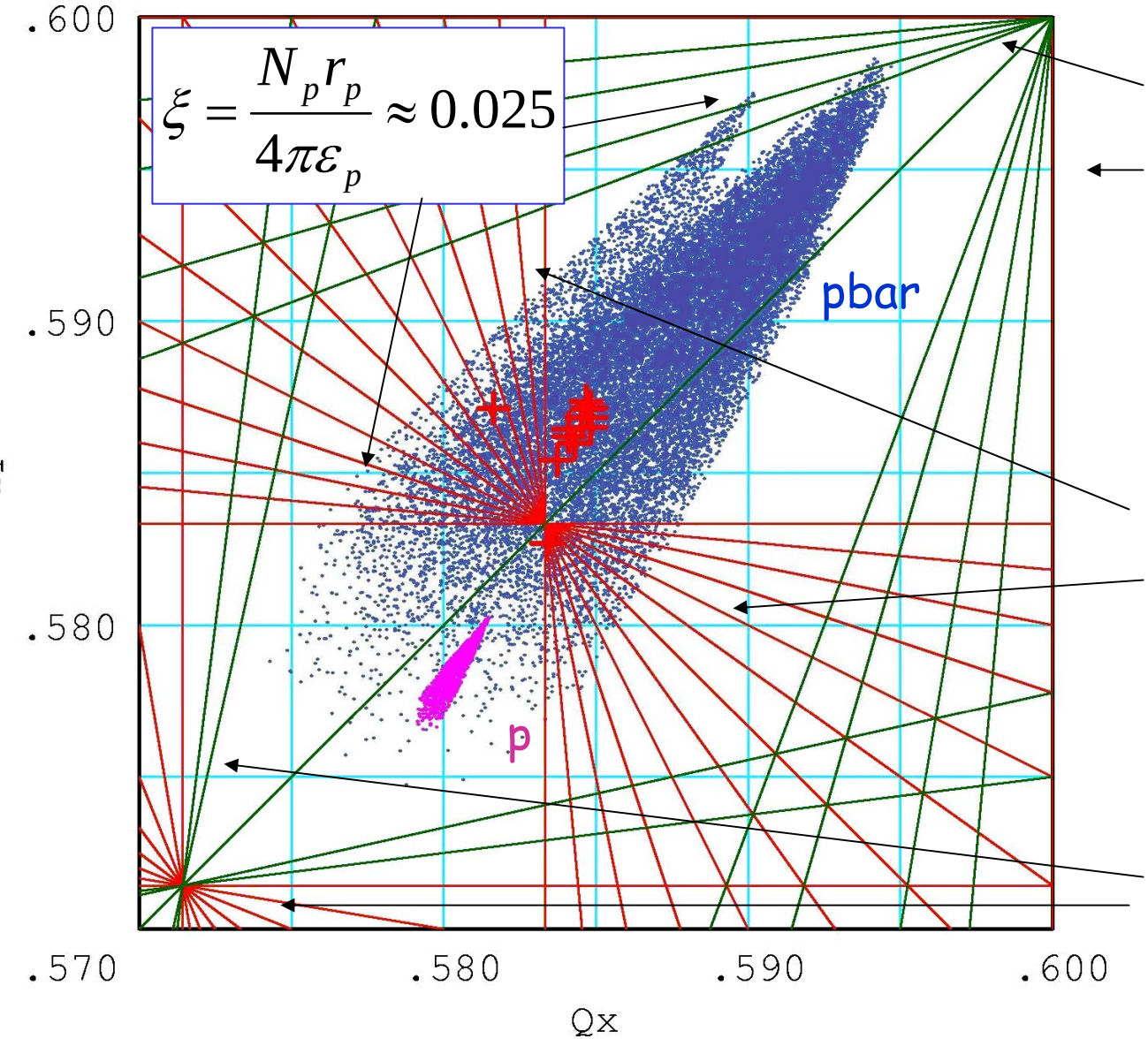
Goal: to increase luminosity above 210e30
by increasing proton intensity

3 stages with gain at each step, decision after each

- Stage Zero:
  - change beta^* and establish optics x 1.10-1.20
- Stage One:
  - performs studies of 2/3 resonance
  - establish new WP below or above 2/3 x 1.0
- Stage Two:
  - increase Np from 240 to 320e9/bunch x 1.25-1.35
  - further increase to 380-400e9/bunch x 1.15-1.25
- Stage Three:
  - switch to 46x41 operation, increase Np x 1.05 – 1.10

TOTAL GAIN: x (1.5-2) in L_peak (>2.1e32), 1.3-1.6 in Int

Situation at LB Now: Confined Beams



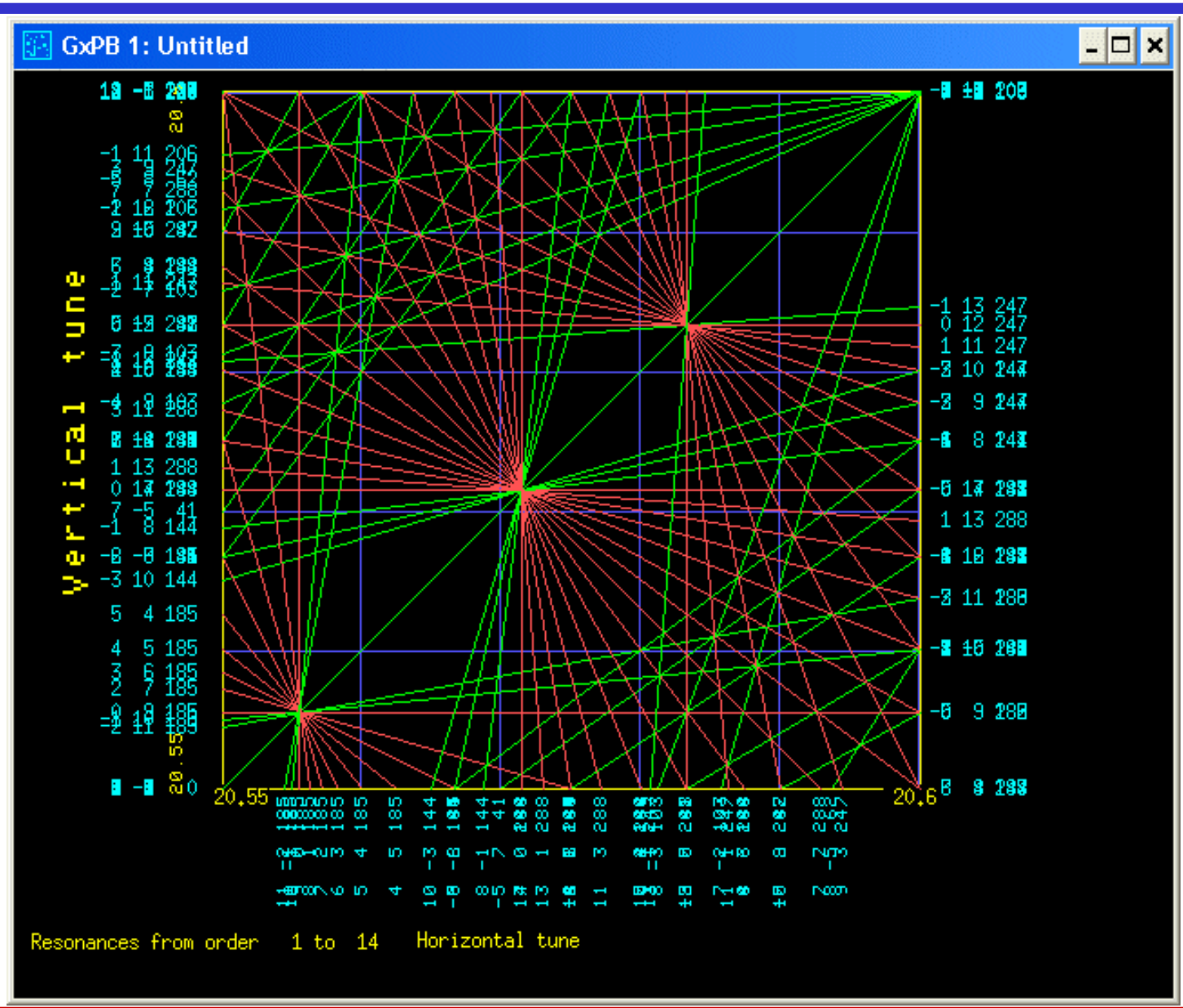
$$\xi = \frac{N_p r_p}{4\pi\varepsilon_p} \approx 0.025$$

5th order resonances:
Q=3/5=0.600 -
EMITTANCE BLOWUP

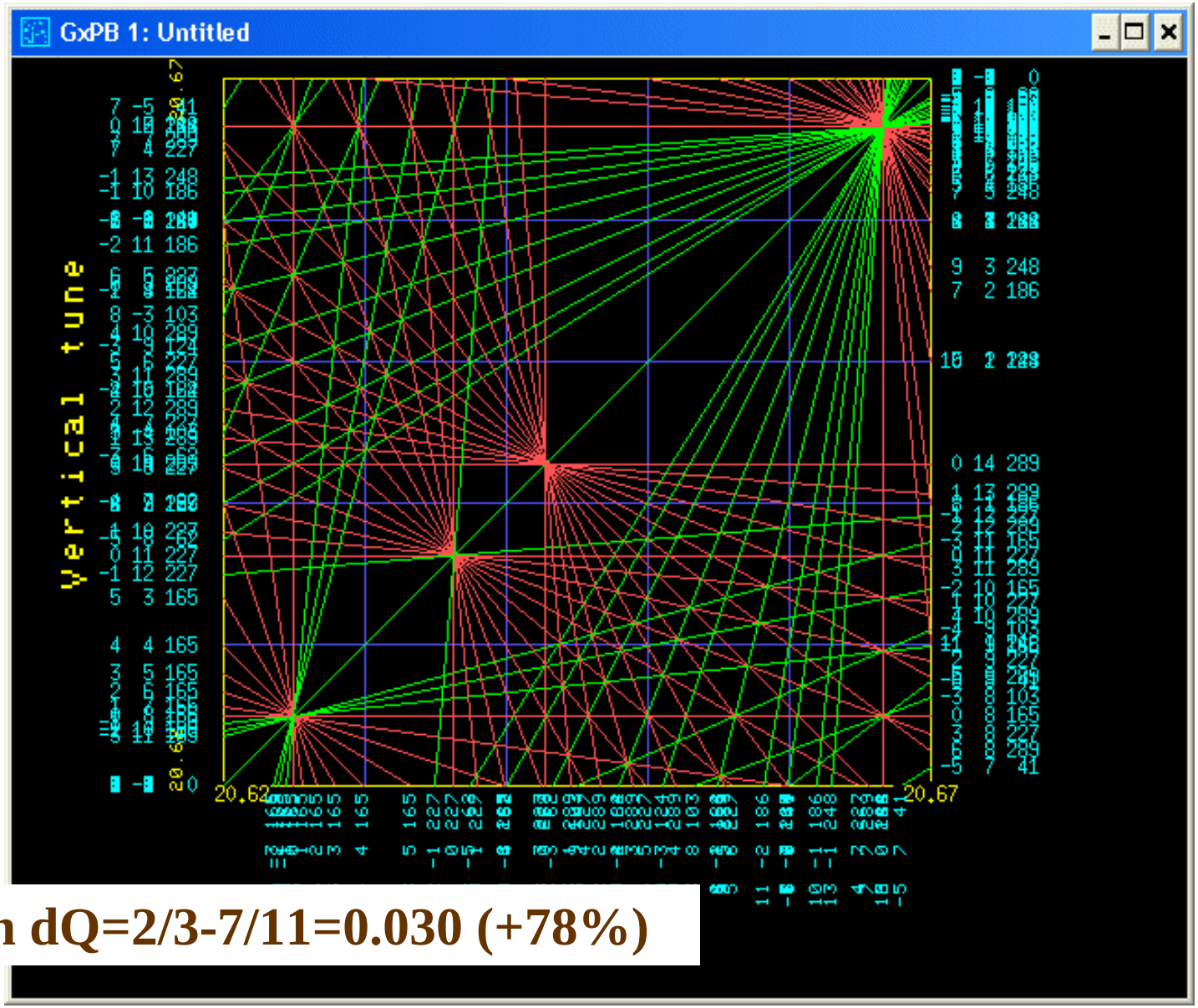
12th order resonances:
Q=7/12=0.583 -
Bad lifetime

7th order resonances:
Q=4/7=0.571 -
HIGH LOSSES

Tune Space Now: 3/5-7/12=0.017

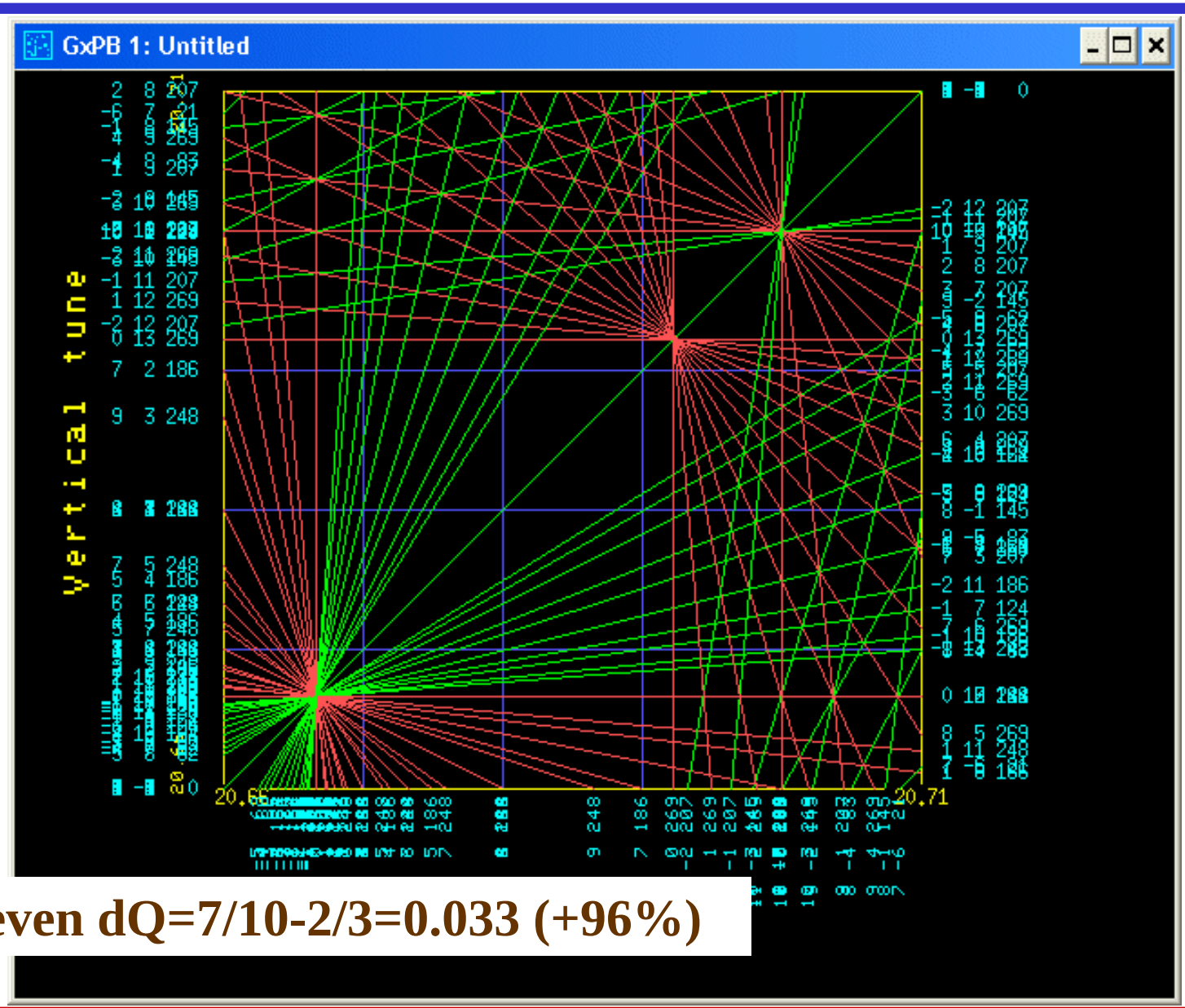


New WP#1: dQ=2/3-9/14=0.024 (+40%)



Or even dQ=2/3-7/11=0.030 (+78%)

New WP#2: dQ=9/13-2/3=0.026 (+50%)



Or even dQ=7/10-2/3=0.033 (+96%)

Which of Two WPs Is Better?

- WP#2 offers bigger space
- WP#1 has the same placement of resonances as now: strong on top (core), weak on bottom (halo)
- WP#1 has 14th order below which may be tolerable → then 11th order offers larger space
- Same may be true for WP#2 (13th →10%) – for core particles
- IMPORTANT NOTES:
  - with 5 pi pbars from RR (only) and 15pi protons, tune spread upto 5-6 sigma particles will be less than ksi by ~ 20-30% (→ possibility to increase Np)
  - chromatic tune spread becomes important for the Np increase as it reduces the tune space → use of octupoles or/and dampers to drop Q' to 0 may be essential for the plan

Stage 0: Beta* Reduction

- To take place in July-Sep'05
- New BPMs are essential for precise optics adjustment - commissioned, OK
- Beta* to be reduced from 35cm to 28 (24?) cm
  - due to hourglass effect, gain is SQRT(1/beta) ~ 10-20%
  - head-on beam-beam resonant driving terms will change, too → need observations and to gain experience
- Resulted lattice and helix will be references for future operation after the change of working point

Stage 1: Change WP

- First, perform studies to evaluate new WP:
  - determine stopband width of 2/3 resonance wrt 3/5 at 150 GeV, may be at LB (1-2 shifts)
  - compare emittance growth rates at 150 GeV at <3/5 and <2/3 (1 shift)
  - check stability of highest possible bunch intensity at 150 and 980 (1x0, 36x0) – to confirm that either octupoles or dampers can handle what MI can provide now (320-330e9 at 150 GeV) (1-2 shifts)
  - Commission new feeddown tune correction schemes (0.5-1 shift)
- Then, change the tunes all the way from 150 to LB
  - on C.O and helices
  - tune and coupling and chromaticity adjustments
  - parsing the squeeze
  - altogether ~4-6 shifts
  - operation @ new WP with present N_p, adjust knobs (1-2 mos)
  - at the end – may gain 5-10% in Integrated luminosity
- When? – Sep'04-Jan'05; no hit on luminosity integral

Stage 2: Increase N_p/bunch

- First, upto what MI can provide now (320e9):
  - increase N_p in 1-2-3 steps; adjust Tevatron parameters in operation
  - commission octupoles or dampers on ramp if reliability or losses will be intolerable; same at LB
  - perform studies in MI to optimize long and transverse emittances, satellites at given intensities
  - optimize DC beam cleaning by TELs at new WP and collimation efficiencies (may be – collimators at 150 and on ramp)
  - all that may take some 3-6 mos
- Then, switch to superbunches in MI:
  - preceded by 20-bunch coalescing studies (C.Bhat)
  - goal intensities 380e9/bunch, <2% satellites, long emittancee 4eVs, about same transverse emittances
  - may take 1-3 mos of studies in parallel to collider operation)
- Goal: 320e9 by May'06; 380e9 by Nov'06

In parallel to Stages 1 and 2 (07/05-04/06)

- Perform following analysis/simulations:
  - estimate stopband width with beam-beam OFF/ON
  - evaluate difference in long-range interaction effects at new WP compared to present one : at 150 and LB
  - decide which WP is better : above or below 2/3
  - SB resonances with smaller beta* and new WP
  - consider the changes in the lattice finctions
  - evaluate relative danger of 9/14 vs 7/12 resonances
  - scallopd near 2/3 vs near 3/5
  - will helix size matter at new WP? Will dependence be different from 1/helix^3
  - effect of octupoles at new WP

Stage 3 (Final) : 46x41 operation

- Switch to operation with (17+17+12) proton x (12+12+17) pbar bunches in the Tevatron:
  - same proton bunch intensity; just one abort gap
  - proportionally 15% lower pbar bunch intensity
  - the scheme will eliminate PACMAN bunches
  - # of interactions per crossing will be 15% lower (CDF and D0 will like that)
- Will require beam studies for:
  - injection logistics and scenario
  - RR studies to inject 17 bunches build time
  - evaluation of effects of 9 coggings at 150 GeV
  - possibility and neccessity of TELs for tune compensation for 5 extra proton bunches
  - importance of 35RFC gaps for DC cleaning
  - total of 2-4 shifts
- Goal: 46x41 by Dec'06-Feb'07

One More Piece – Needs More Thought

- PR=Proton refill:
  - every 3-5 hrs
  - remove protons at LB
  - decelerate pbars
  - inject fresh protons
  - accelerate, squeeze, scrape
  - altogether takes <30 min
  - do that 3-4 times with one pbar load
  - lose <15% of pbars (larger emm),
  - luminosity: pbar hit <-10%, proton boost +30%
  - total effect ~20% in peak, 5-10% in integral

  (depends on refill cycle time)